

Meta-analysis evaluating music interventions for anxiety and pain in surgery

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Background: This study aimed to evaluate anxiety and pain following perioperative music interventions compared with control conditions in adult patients.

Methods: Eleven electronic databases were searched for full-text publications of RCTs investigating the effect of music interventions on anxiety and pain during invasive surgery published between 1 January 1980 and 20 October 2016. Results and data were double-screened and extracted independently. Random-effects meta-analysis was used to calculate effect sizes as standardized mean differences (MDs). Heterogeneity was investigated in subgroup analyses and metaregression analyses. The review was registered in the PROSPERO database as CRD42016024921.

Results: Ninety-two RCTs (7385 patients) were included in the systematic review, of which 81 were included in the meta-analysis. Music interventions significantly decreased anxiety (MD -0.69 , 95 per cent c.i. -0.88 to -0.50 ; $P < 0.001$) and pain (MD -0.50 , -0.66 to -0.34 ; $P < 0.001$) compared with controls, equivalent to a decrease of 21 mm for anxiety and 10 mm for pain on a 100-mm visual analogue scale. Changes in outcome corrected for baseline were even larger: MD -1.41 (-1.89 to -0.94 ; $P < 0.001$) for anxiety and -0.54 (-0.93 to -0.15 ; $P = 0.006$) for pain. Music interventions provided during general anaesthesia significantly decreased pain compared with that in controls (MD -0.41 , -0.64 to -0.18 ; $P < 0.001$). Metaregression analysis found no significant association between the effect of music interventions and age, sex, choice and timing of music, and type of anaesthesia. Risk of bias in the studies was moderate to high.

Conclusion: Music interventions significantly reduce anxiety and pain in adult surgical patients.

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Introduction

Worldwide, an estimated 266–360 million surgical procedures are undertaken annually according to the WHO¹. Surgical patients often suffer from preoperative anxiety and postoperative pain; recent data suggest that 75 per cent of patients facing surgery are anxious, despite anxiety-decreasing measures^{2,3}. Preoperative anxiety can increase the level of postoperative pain⁴ and, despite interventions to reduce postoperative pain, approximately 40–65 per cent of patients experience moderate to severe pain after surgery^{5,6}.

As the use of analgesics has inherent side-effects⁶, music interventions have been suggested as a way to reduce perioperative anxiety^{7,8} and postoperative pain^{6,9}. Despite a large number of studies, perioperative music

interventions are still not used widely. Two recently published meta-analyses^{9,10} on the effect of music interventions in different hospital procedures, and of different forms of perioperative art therapy, reported small to moderate beneficial effects on anxiety and pain in surgical, but also in non-surgical, patients. Research on music interventions in healthcare often identifies heterogeneity in study populations and lack of negative studies possibly owing to publication bias. These factors may be the reason why perioperative music interventions are not often applied in clinical practice.

The purpose of the present study therefore was to perform a systematic review and meta-analysis of all RCTs evaluating the effects of music interventions on patients' anxiety and pain before, during and after exclusively invasive surgical procedures.

Methods

This systematic review and meta-analysis was conducted according to the PRISMA statement¹¹. The review was registered in the PROSPERO database (<https://www.crd.york.ac.uk/PROSPERO/>) as record number CRD42016024921.

Search strategy

A dedicated biomedical information specialist helped define the search strategy. The electronic databases Embase, MEDLINE, OvidSP, Web of Science, Scopus, PsycINFO, OvidSP, CINAHL, Cochrane Central Register of Controlled Trials, PubMed publisher and Google Scholar were searched for publications on the effect of music interventions before, during and after surgery published between 1 January 1980 and 20 October 2016 (*Appendix S1*, supporting information).

Study selection

Titles and abstracts of articles identified by the search, and full texts of those deemed potentially eligible, were double-screened for relevance by four investigators independently. Inclusion criteria for the systematic review were: full-text article of an RCT; investigating effects of music interventions on anxiety and/or pain; mean age of participants at least 18 years; written in English; invasive surgical procedures, either open or laparoscopic, such as abdominal surgery or total knee surgery; use of general anaesthesia, regional anaesthesia or both; use of any recorded or live music intervention having melody, harmony and rhythm; intervention offered by a researcher or a music therapist; and intervention performed in a hospital or outpatient clinic. Studies involving non-invasive procedures such as endoscopy were excluded, as were those using quasi- or pseudo-randomization. Nature sounds were considered only when they were used in addition to music. If populations overlapped between studies, only the most recent or most complete study was included. Studies were included in the meta-analysis only if they included measures of dispersion of a particular outcome. A fifth investigator was consulted in the event of disagreement about inclusion of an article.

Data extraction

Data were extracted and checked by three authors independently. The following study characteristics were recorded: author, year of publication, journal, number of patients, sex ratio, mean age, inclusion period, mean follow-up,

ethical approval, outcome scale used, type of surgery, type of anaesthesia, timing of the music intervention (before, during or after surgery), recorded *versus* live music intervention and description of intervention, and type of control group. Primary outcomes were mean anxiety scores and mean pain scores (including measures of dispersion) in the intervention and control groups measured at baseline and at the end of the study or within 7 days after operation. When available, outcome data on change from baseline, including measures of dispersion for both intervention and control groups, were also extracted. If a study used multiple time points, only the first and final time points were considered (at most 7 days after surgery).

Statistical analysis

Data were analysed using Review Manager version 5.3.5 (The Nordic Cochrane Centre, Copenhagen, Denmark). Outcome measures were pooled using the inverse-variance method in a random-effects model. Standardized mean differences (MDs) were calculated with Hedges' adjusted g using pooled weighted standard deviations. Effect sizes were summarized with 95 per cent confidence intervals. In five studies only an i.q.r. or range was provided; the i.q.r. was divided by 1.35¹² and the range by 4 to produce approximations of the standard deviation. Data were summarized and presented visually in forest plots. Funnel plots were constructed to investigate publication bias. Heterogeneity among included studies was analysed with both the Cochran Q statistic and the I^2 index. Risk of bias among studies was assessed by three reviewers using the Cochrane Collaboration risk-of-bias assessment tool¹³. Two-sided statistical significance was inferred at $P < 0.050$.

A metaregression analysis was conducted in Stata[®] release 14 (StataCorp, College Station, Texas, USA) to investigate possible associations between study characteristics and the effect of music. The following subgroups were chosen *a priori* for subgroup analyses: timing of intervention (before, during or after surgery); type of anaesthesia (general or regional); type of music intervention (chosen by investigator, chosen by patient from a list provided, or patient's own music). During data collection, other variables that could potentially influence the intervention effect were added: single (only 1 intervention during the course of the study) or multiple (several music interventions during the course of the study) music interventions; sex; and age. Multivariable metaregression analyses were carried out first with all variables, and subsequently based on the results of the subgroup analyses and univariable metaregression analyses, including only variables that were either statistically significant or had a β -coefficient larger than the corresponding standard error.

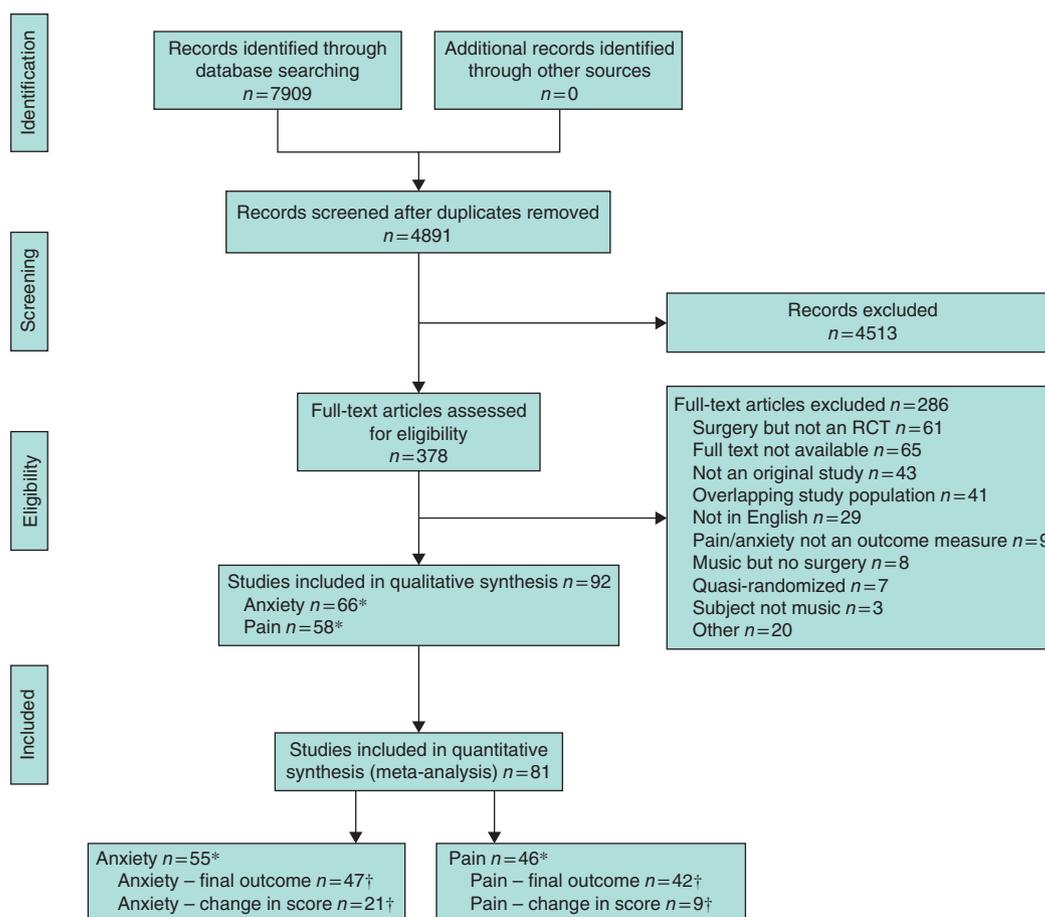


Fig. 1 Flow chart showing selection of studies for review. *Some studies reported both anxiety and pain outcomes. †Some studies reported both final outcome and change in scores

Back-transformations were calculated in Microsoft Excel® (Microsoft Corporation, Redmond, Washington, USA) by multiplying the MD of both State-Trait Anxiety Inventory (STAI)¹⁴ and visual analogue scale (VAS) scores for anxiety and VAS scores for pain with the typical among-person standard deviation, which was derived from pooling baseline standard deviations of control arms from studies that reported these.

Results

The literature search resulted in the inclusion of 92 RCTs^{8,15–105} in the systematic review (7385 patients). Eighty-one of these were included in the meta-analysis (Fig. 1). Details of study characteristics are presented in Table S1 (supporting information).

The studies investigated music interventions in many types of surgery and in different patient populations, with a mean(s.d.) age of 51.7(10.4) years and predominance of women (57 per cent). Most studies evaluating anxiety

outcomes used the STAI (55 per cent) and/or a VAS (43 per cent); the studies evaluating pain outcomes used a VAS (79 per cent) and/or a numerical rating scale (21 per cent). In the majority of studies (67 per cent on anxiety, 64 per cent on pain) the effects of single interventions were investigated. Music interventions were offered before operation (anxiety: 17, 26 per cent; pain: 3, 5 per cent), during surgery (anxiety: 13, 20 per cent; pain: 13, 22 per cent), after operation (anxiety: 13, 20 per cent; pain: 21, 36 per cent), at multiple times (anxiety: 22, 33 per cent; pain: 21, 36 per cent) or not specified (anxiety: 1, 2 per cent). Four studies (4 per cent) investigated anxiety and/or pain-reducing effects of live music therapy provided by a music therapist, whereas all other studies used recorded music interventions. Control arms of studies provided standard medical care without (28, 30 per cent) or with (11, 12 per cent) a resting period, reported no music (13, 14 per cent), reported no intervention (17, 18 per cent), used a device with sham sounds (8, 9 per cent), provided headphones without music (6, 7

Table 1 Results of meta-analyses for the outcome anxiety (55 studies) and pain (46 studies)

	No. of studies	Mean difference*	P	I ² (%)
Anxiety				
Final anxiety score	47	-0.69 (-0.88, -0.50)	< 0.001	87
Change in anxiety score*	21	-1.41 (-1.89, -0.94)	< 0.001	95
Subgroup analyses				
Selection of music				
Chosen by patient from list provided	23	-0.71 (-0.99, -0.43)	< 0.001	88
Chosen by investigator	19	-0.67 (-0.97, -0.36)	< 0.001	87
Patient's own	4	-0.45 (-0.82, -0.07)	0.020	75
Timing†				
Preoperative	13	-1.10 (-1.53, -0.66)	< 0.001	89
Perioperative	10	-0.57 (-1.06, -0.09)	0.020	92
Postoperative	10	-0.66 (-1.07, -0.25)	0.002	87
No. of interventions				
Single	34	-0.76 (-1.02, -0.50)	< 0.001	91
Multiple	13	-0.51 (-0.64, -0.38)	< 0.001	0
Type of anaesthesia‡				
General	13	-0.47 (-0.71, -0.23)	< 0.001	69
General, only perioperative music	1	-0.23 (-0.62, 0.17)	-	
Regional	14	-0.88 (-1.34, -0.42)	< 0.001	92
Pain				
Final pain score	42	-0.50 (-0.66, -0.34)	< 0.001	78
Change in pain score*	9	-0.54 (-0.93, -0.15)	0.006	84
Subgroup analyses				
Selection of music				
Chosen by patient from list provided	21	-0.55 (-0.81, -0.28)	< 0.001	84
Chosen by investigator	16	-0.47 (-0.67, -0.26)	< 0.001	65
Patient's own	5	-0.26 (-0.56, 0.04)	0.090	61
Timing†				
Preoperative	3	-0.73 (-1.54, 0.08)	0.080	84
Perioperative	10	-0.18 (-0.36, 0.00)	0.050	44
Postoperative	19	-0.53 (-0.79, -0.28)	< 0.001	82
No. of interventions				
Single	32	-0.47 (-0.65, -0.29)	< 0.001	80
Multiple	10	-0.62 (-0.93, -0.30)	< 0.001	72
Type of anaesthesia‡				
General	23	-0.55 (-0.72, -0.39)	< 0.001	55
General, only perioperative music	5	-0.41 (-0.64, -0.18)	< 0.001	9
Regional	8	-0.41 (-0.80, -0.03)	0.040	84

Values in parentheses are 95 per cent confidence intervals. *Some studies reported on the primary outcome and change in score. †Studies included in analysis used either preoperative, perioperative or postoperative interventions, not multiple. ‡Studies included in analysis used either general or regional anaesthesia, not both.

per cent) or with noise-blocking features (2, 2 per cent), used midazolam (1, 1 per cent) or had an unclear description (5, 5 per cent). Eleven RCTs^{15–25} (12 per cent) did not report on quantitative data and could not therefore be included in the quantitative analyses (Table S1, supporting information).

Risk-of-bias assessment

The included studies had a moderate to high risk of bias (Fig. S1, supporting information). As blinding of patients to music interventions during surgery is only feasible under general anaesthesia, the assessment was limited to blinding of personnel involved in patient care. All included studies reported the use of randomization, but studies that did not

report specific methods of sequence generation or allocation concealment were assessed as having an unclear risk of selection bias. Few studies reported on attrition bias (43, 47 per cent), blinding of data collectors (33, 36 per cent), reporting bias (16, 17 per cent) and other bias (4, 4 per cent); in most studies, therefore, a majority of bias regarding these variables was unclear. Inspection of funnel plots for the presence of publication bias revealed a tendency towards asymmetry in the funnel plot for anxiety, but not in that for pain (Figs S2 and S3, supporting information).

Effect of music interventions on anxiety and pain

Pooling data on the different outcome measures of anxiety from the intervention and control groups resulted

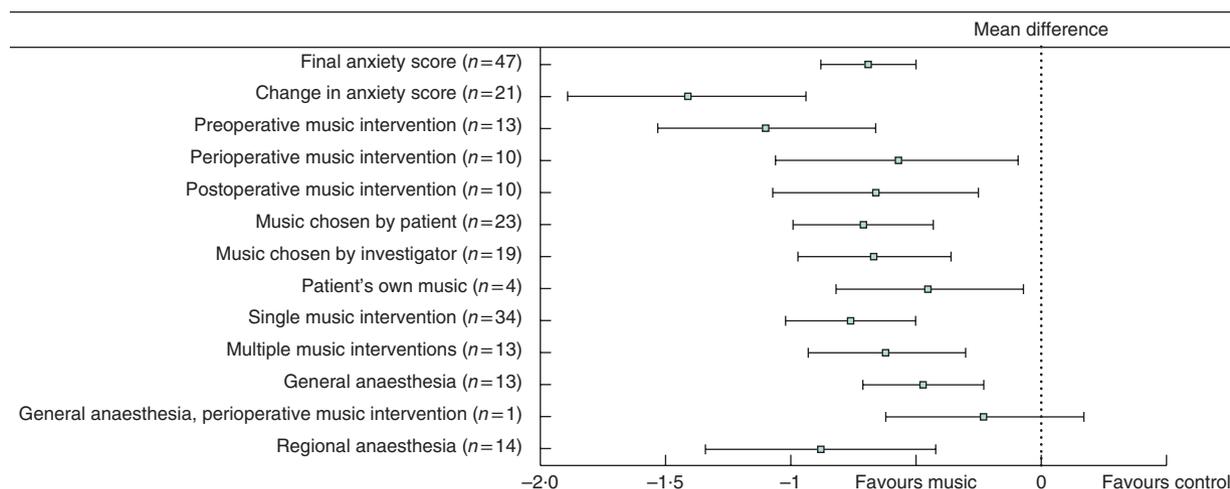


Fig. 2 Summary forest plot for anxiety. Mean differences between music intervention and control groups are shown with 95 per cent confidence intervals. The number of studies in each subgroup analysis is indicated

in a moderate to large statistically significant MD of -0.69 (95 per cent c.i. -0.88 to -0.50 ; $P < 0.001$). Pooling of the data on mean change in anxiety scores between postoperative outcomes and preoperative baseline measurements from the 21 studies that reported this revealed a large effect of music interventions in reducing anxiety, with a MD of -1.41 (-1.89 to -0.94 ; $P < 0.001$) (Table 1 and Fig. 2; Fig. S4, supporting information).

Pooling of the different outcome measures of pain resulted in a statistically significant MD of -0.50 (-0.66 to -0.34 ; $P < 0.001$), indicating a moderate effect of music interventions in reducing pain. Pooling of the data on mean change between postoperative outcomes and preoperative baseline measurements in pain scores (9 studies) yielded a MD of -0.54 (-0.93 to -0.15 ; $P = 0.006$) (Table 1 and Fig. 3; Fig. S4, supporting information).

To facilitate clinical interpretation, effect sizes from the main analyses were back-transformed, demonstrating that music interventions led to a mean 6.3-point decrease on the 20–80-scale of the STAI and a mean 21-mm decrease on a 100-mm VAS for anxiety, and to a mean 10-mm decrease on a 100-mm VAS for pain.

Subgroup analyses

Subgroup meta-analyses showed that music interventions before, during and after surgery all led to a reduction in anxiety, with the largest effect seen when offered before surgery (Table 1 and Fig. 2). Postoperative interventions had the largest effect in decreasing pain (Table 1 and Fig. 3). Pooled analysis of the five studies^{75,81,84,88,105}

that investigated the effects of music interventions solely during general anaesthesia showed a statistically significant decrease in pain. Only one study⁸¹ investigated the effect of music interventions during general anaesthesia on anxiety, and demonstrated no significant difference between the music and control groups. Fourteen studies^{28,33,37,47,51,53,55,58,61,66,77,80,93,96} investigating music interventions during regional anaesthesia showed a large statistically significant anxiety-reducing effect. A moderate statistically significant pain-reducing effect was found for the eight^{47,51,58,60,61,66,77,96} studies that investigated music interventions during regional anaesthesia. Pain reduction was enhanced by offering multiple interventions rather than a single music intervention^{29,32,34,35,38,46,52,76,77,101}. An opposite trend was seen for anxiety, where a single intervention had a larger effect^{8,27,28,30,36,37,39,40,42,45,47,49,51,55,58,61,63,66,67,70,72–74,78,80,81,86,87,94–97,100,102}. The largest beneficial effect on both anxiety and pain was seen when patients selected music from a list provided. The smallest benefit was found when patients had freely chosen the music themselves^{39,58,60,89,92,93,95}.

Studies that had at least three items with low risk of bias were also analysed separately, resulting in a smaller but statistically significant MD of -0.61 (95 per cent c.i. -0.94 to -0.29 ; $P < 0.001$) for anxiety and of -0.34 (-0.55 to -0.13 ; $P = 0.002$) for pain (Figs S5 and S6, supporting information).

Metaregression

Overall, heterogeneity was high among studies (Table 1). Results of univariable and multivariable metaregression

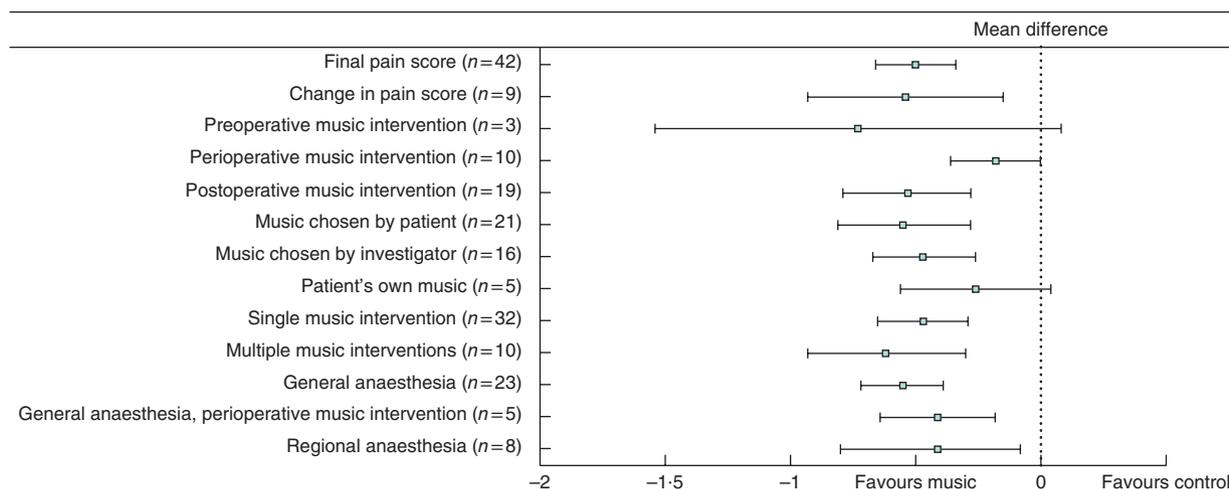


Fig. 3 Summary forest plot for pain. Mean differences between music intervention and control groups are shown with 95 per cent confidence intervals. The number of studies in each subgroup analysis is indicated

analysis are shown in *Tables S2* and *S3* (supporting information) respectively. These results were consistent with those of the subgroup meta-analyses. A statistically significant association between preoperative music interventions and pain was found in the data-driven multivariable regression analysis of this outcome. None of the other explanatory variables were significant, and no evidence was found for an association between any of the other variables and anxiety or pain.

Discussion

This meta-analysis found a statistically significant decrease in both anxiety and pain in adults receiving music interventions before, during or after surgery. The effect on anxiety seemed largest when the music intervention was offered before operation; however, music interventions offered during and after surgery also significantly reduced anxiety. Postoperative music interventions were most likely to reduce pain; a significant pain-reducing effect of preoperative music was also seen in the data-driven multivariable regression analysis. As preoperative anxiety is associated with postoperative pain⁴, pain reduction noted after preoperative music interventions might be the result of decreased anxiety. In the present meta-analysis, the mean changes in anxiety and pain from baseline values showed even larger anxiety- and pain-reducing effects of music than did the direct comparison of postintervention outcomes. Previous meta-analyses that investigated music interventions also included other interventions¹⁰, or other procedures that did not involve surgery⁹. Moreover, they included fewer RCTs. The results presented here underline and reinforce the findings of other studies^{7,9,10,106}. The more specific

inclusion criteria in the present meta-analysis, which investigated music interventions alone in exclusively surgical populations, emphasize the effect of the intervention, and make it more applicable in practice. The analysis of mean changes in scores between intervention and control situations, with outcome scores corrected for baseline values, reveals the true effect of the intervention more than previous studies have shown, and should encourage its implementation in surgery.

An important finding is that many different music interventions each have positive effects. Although most of the music interventions used in the studies were bound by restrictions, such as slow, soft, relaxing music (*Table S1*, supporting information), the effect does not seem to be related to one specific type of music. Moreover, it has been suggested that individual music preference is important to the effect of a music intervention⁵⁴. Effect sizes in the present study were slightly higher when patients chose music from a list provided. The small number of studies that investigated freely chosen music compared with music selected by the investigator and preselected music makes it hard to draw definite conclusions about the importance of individual preferences. Besides individual music preference, specific features of the music intervention such as rhythm and harmony, and the use of specific instruments like string instruments, also seem important features in anxiety and pain reduction¹⁰⁷. A placebo effect cannot be ruled out as the studies relied on self-reporting. It could be argued that a placebo effect is beneficial anyway¹⁰⁸, in this instance reducing anxiety and pain. However, the subgroup analysis of perioperative music interventions during general anaesthesia did show a

statistically significant pain-reducing effect. Factors such as distraction strategies and interference from personnel and observers do not play a role when patients are under general anaesthesia^{75,81,84}, nor do the psychological effects of listening to music. These considerations militate against a mere placebo effect.

Overall, risk of bias in the included studies was moderate to high. Many studies did not adequately address methodological considerations (randomization techniques and power) and risk of bias, and were therefore scored as having an unclear risk. In randomized trials of non-pharmacological treatments, it may be difficult to blind the relevant parties and to exclude the influence of the provider's expertise¹⁰⁹. Although the nature of music interventions makes it hard to perform double-blinded studies, suitable randomization and reporting following the CONSORT checklist for non-pharmacological trials¹¹⁰ could help minimize the risk of bias in future trials. No clear association was found for any explanatory variable in either subgroup analyses or univariable meta-regression analyses. A statistically significant association was found between preoperative music interventions and pain in the data-driven multivariable regression analysis. However, the absence of this effect in the subgroup meta-analysis, the small number of studies investigating the effect of preoperative music interventions on pain, and the possible issue of multiple testing make the reproducibility of this result questionable.

This study has strengths and limitations. A dedicated biomedical information specialist was consulted to identify all publications on this subject in the scientific literature. Bias was limited by excluding studies that generated randomization sequences inadequately. The present review is, however, limited by the overall high level of heterogeneity. Even though the search was limited to surgical patients, there is a wide variety of surgical procedures in the study population, with diverse methods of anaesthesia. These issues in part explain the large degree of heterogeneity. Moreover, the diverse control conditions also create variety in study populations. Publications might have been missed as a result of the language restriction (*Fig. 1*). The funnel plot for anxiety raises the possibility of publication bias. Previous publications of mainly favourable results might affect the conclusion of this review.

This review provides evidence for the implementation of music interventions before, during and after surgery. Preoperative anxiety and postoperative pain are clinically relevant issues that may determine morbidity, duration of hospital stay and even mortality². Alleviating these factors may improve clinical outcomes and quality of life, may also lead to earlier discharge from hospital, and thus may help to reduce healthcare costs¹¹¹. Pain relief after

surgery continues to be an important medical challenge¹¹² and it has been shown that a minimum 12 (95 per cent c.i. 9 to 15)-mm reduction in VAS pain score signifies clinical relevance¹¹³. Based on this, at least some of the patients in the music intervention groups included in this meta-analysis experienced a clinically relevant reduction in pain. Defining minimally important differences to determine clinically relevant effects is challenging¹¹⁴. No clear minimally important differences for anxiety have been defined; however, minimally important differences for depression have previously been inferred at an MD of 0.50, and an MD of 0.24 has also been reported¹¹⁴. The pooled MD of -0.69 for anxiety reported in the present analysis therefore appears clinically relevant. Some of the included studies have also investigated other parameters to evaluate the efficacy of music interventions. Music has, for instance, been shown to reduce the use of analgesics after surgery^{24,35,39,60,76,82}, and was more effective in reducing preoperative anxiety than orally administered midazolam⁸. More foot movement and a reduction in the rate of delirium was found following music interventions after hip and knee surgery in elderly patients⁶⁹. Furthermore, duration of hospital stay after mastectomy was shorter for patients receiving music interventions compared with controls¹⁰².

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Supporting information

Additional supporting information can be found online in the Supporting Information section at the end of the article.